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References:

Weaver, K., D. Janney, & H. Davis, "Engaging Audiences About Rain, Snow and Storms: The Global Precipitation Measurement Mission's Rain EnGAUGE," *The Earth Scientist*, Volume XXX, Issue 2. http://www.nestanet.org/cms/sites/default/files/journal/USRA_TES_Sum2014.pdf

Data Sources: Locations of events and approximate attendance provided by the event hosts to Kristen Weaver. Grateful acknowledgment to Dr. Dalia Kirschbaum (617, NASA/GSFC), Deputy Project Scientist for Applications for the GPM mission and lead for the GPM Education & Communication Team, and to Jacob Reed (617, NASA/GSFC & Telophase) for creating the Rain EnGAUGE website, including the project logo, <https://pmm.nasa.gov/education/rain-engauge>.

Technical Description of Figures:

Left Top: Poster created by students to advertise the Rain EnGAUGE event held at Silver Spring International Middle School in Silver Spring, Maryland. Event organizer was science teacher Molly McMahon.

Left Middle: Rain EnGAUGE logo, created by Jacob Reed (617, NASA/GSFC & Telophase)

Left Bottom: Oluwale Oluwafemi, teacher and researcher at the Nigeria Space Agency's Centre for Geodesy and Geodynamics, presents about GPM as part of his Rain EnGAUGE event.

Center: Map (using Google Maps) of the locations where known Rain EnGAUGE events were planned. Most events were from January through November 2014, but a few occurred in 2015, as late as September.

Table: List of online suggested activities and electronic materials available on the Rain EnGAUGE website, part of GPM's Precipitation Education page.

Right Top: Students from a summer camp in Murfreesboro, Tennessee, enjoy their GPM outreach materials, sent for the Rain EnGAUGE event hosted by their teacher, David Lockett.

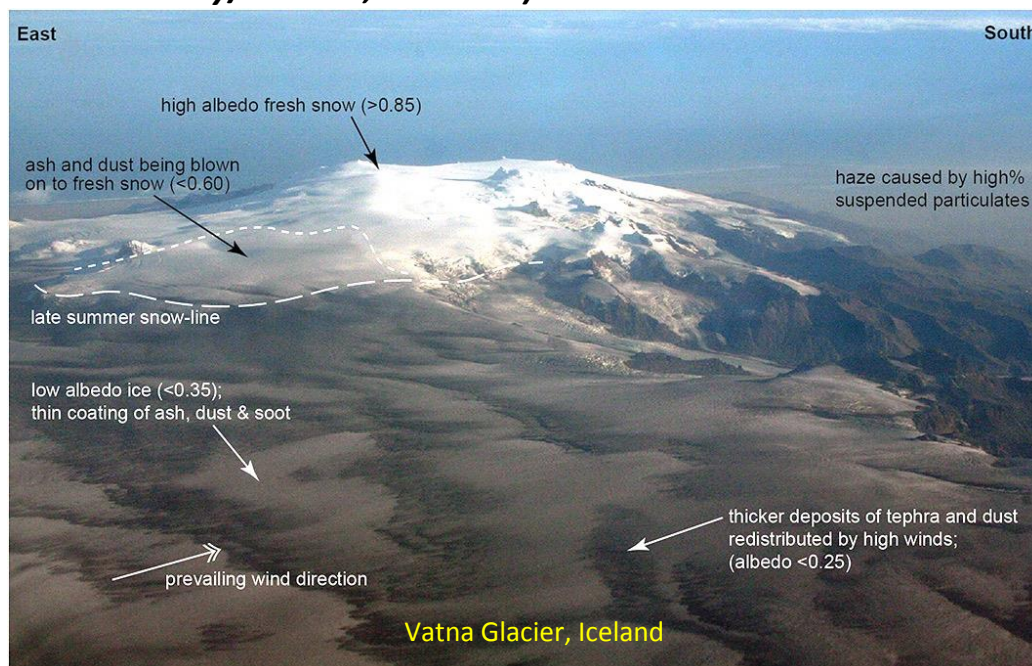
Right Bottom: Kids reading books about weather as part of the Rain EnGAUGE event held at Bridges Prep K-6 STEM School in Beaufort, South Carolina, organized by teacher Loria Rutland and her 2nd grade class.

Scientific significance, societal relevance, and relationships to future missions: The purpose of the Rain EnGAUGE project was to make resources developed by the GPM education and communication team easily accessible for others to help them plan their own outreach events and further spread information about the mission and precipitation science, magnifying the effect of the small GPM core team. As such, the significance is in sharing the scientific information from the GPM mission in a way understandable to students, teachers, and the general public, rather than furthering the science itself. Through the known events held, thousands more people have learned about NASA Earth science generally and GPM specifically. As the resources were freely available online, other events may have been held without any assistance from the GPM team. The concept of the program has been shared with teams from other missions, to allow them to use lessons learned from the project to help spread their own science messages.

Alaska, Greenland, Iceland and Patagonia are Active Dust Producing Regions

Santiago Gassó

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High-latitude glaciers and ice sheets are expected to retreat during the 21st century. In these environments dust activity can occur during cold dry conditions. An international and multidisciplinary collaboration assessed the state of knowledge and current understanding of contemporary dust activity of high latitude dust sources. Possible impacts (some of them already observed) include changes in air quality, snow/ice albedo and nutrient deficient marine ecosystems.



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References:

Bullard, J.¹, Baddock, M.¹, Bradwell, T.², Crusius, J.³, Darlington, E.¹, Gaiero, D.⁵, Santiago Gassó⁴, Gisladdottir, G., Hodgkins, R.¹, McCulloch, R.², McKenna-Neuman, C.⁷, Mockford, T.¹, Stewart, H.², Thorsteinsson, T.⁶, (2016) “**High-latitude dust in the Earth system**”, Review of Geophysics, 54, doi:10.1002/2016RG000518.

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Data Sources: All visible RGB composites obtained from satellite images are from open access NASA Level-1 & Atmosphere Archive and Distribution System (LAADS) Distributed Active Archive Center (DAAC), Goddard Space Flight Center and Google Earth Engine (Landsat).

Technical Description of Figures:

Left image: MODIS Aqua image on 4 December 2012 showing a major dust plume originating from the Copper River valley and extending >200 km over the Gulf of Alaska. The dust cloud reaches a region known to be deficient of the micronutrient Fe.

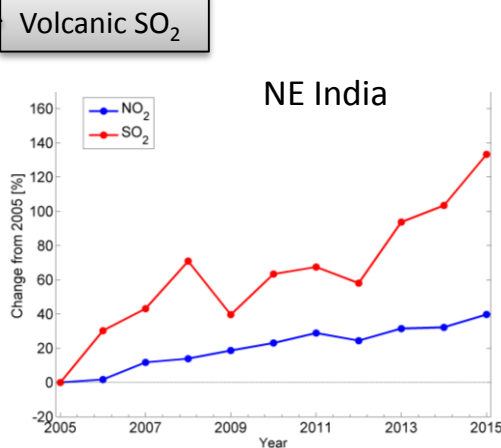
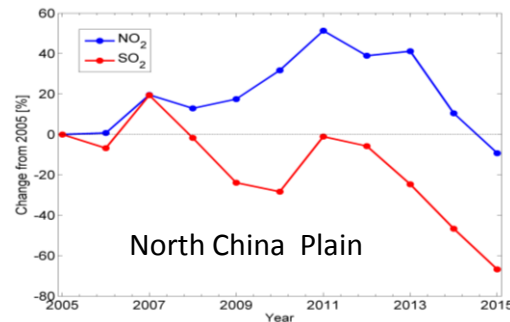
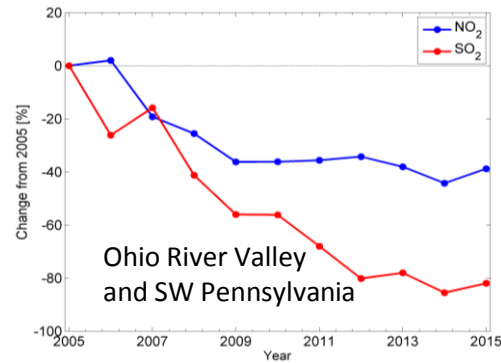
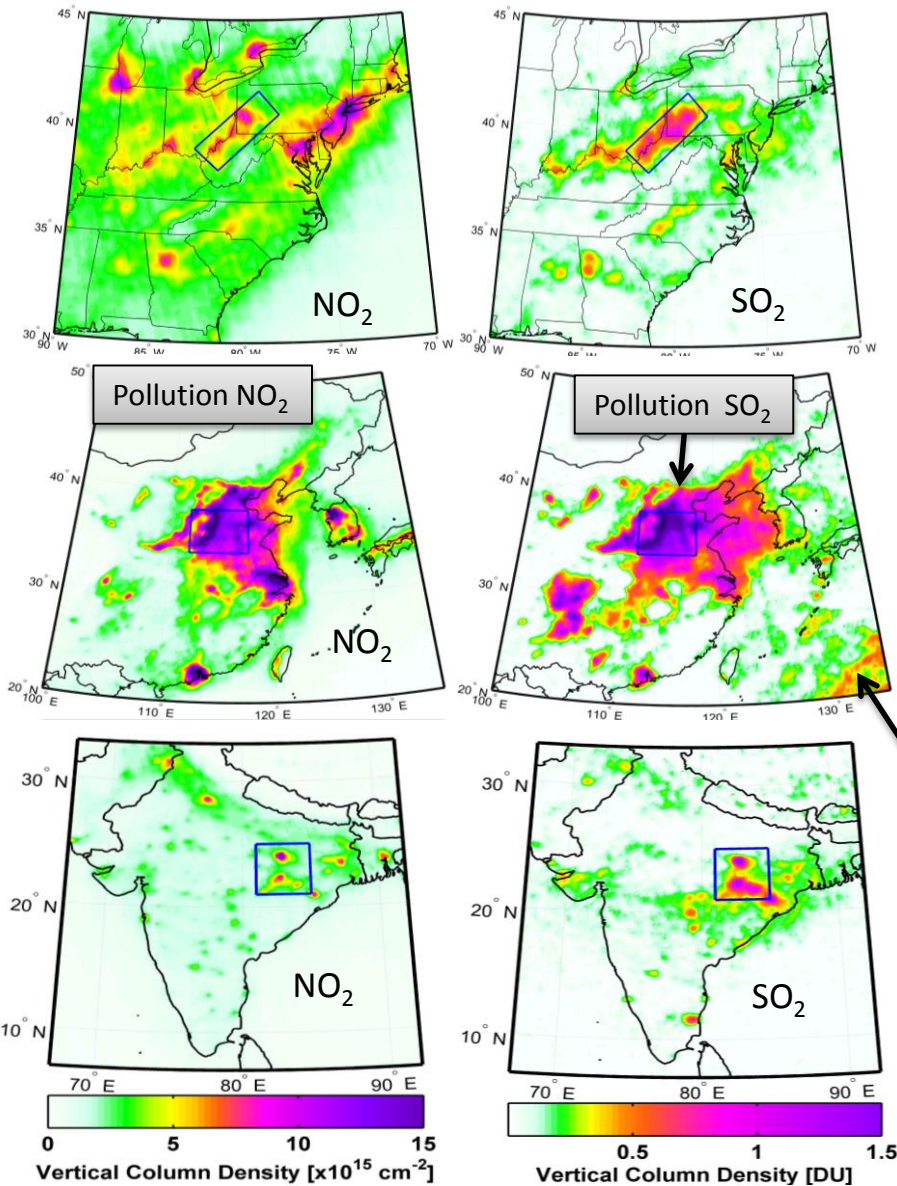
Right image: Oblique aerial view of the dust and ash covering Vatnajökull (Vatna in English) Glacier, Iceland. The photo was taken on 13 September 2011, three months after the Grimsvötn eruption. Note the clear demarcation between highly reflective fresh snow and much darker ash/dust-covered ice on the Örfajökull volcano. Also, note the uneven pattern of wind-blown redistributed surface sediment and high levels of particulates in suspension—evident as visibility-reducing haze (right distance).

Scientific significance, societal relevance, and relationships to future missions: Under contemporary environmental conditions 80–100 Tg yr⁻¹ of dust is contributed to the global dust cycle from high-latitude sources; this very rough estimate represents up to 5% of the global dust budget. However, with receding glaciers and ice fields as well as expansion of human settlements towards high latitudes, it is expected that air quality issues and regional aerosol direct effects will become more apparent. In addition, Aeolian deposition of glacier silt will increase over nutrients deficient marine ecosystems with unknown biogeochemical impacts. Current understanding of high-latitude dust in the Earth system, even at relatively small scales, requires a multidisciplinary approach combining expertise in geomorphology, glaciology, meteorology, oceanography, sedimentology, atmospheric sciences, and other specializations. It also requires the use of a range of research tools including fieldwork, experimentation, observational networks, modeling and especially remote sensing.



Complex Regional Trends (2005-2015) in NO_2 and SO_2 Pollution from Aura's Ozone Monitoring Instrument (OMI)

Nick Krotkov (614) & many others



On April 12, 2016, President Obama uses OMI NO_2 data to explain how pollution affects our planet: <https://www.youtube.com/watch?v=LKe5FdKlNJs>

TOP: over Eastern US NO_2 and SO_2 pollution have decreased by 40% & 80%, "thanks in large part to new rules to protect our air". US Environmental Protection Agency's (EPA) uses OMI NO_2 data in Air Trends Report (<https://gispub.epa.gov/air/trends/report/2016>)

Middle: NO_2 pollution over NE China has declined by 50% since its peak in 2011 and is now at the same level as in 2005. SO_2 pollution has declined by 80% since its peak in 2007 and is now 60% less than in 2005.

Bottom: Over NE India where many new coal-fired power plants were built, NO_2 pollution increased by ~40%, while SO_2 pollution increased by 140%



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Data Sources: Aura Ozone Monitoring Instrument (OMI) SO₂ and NO₂ NASA standard products. The Dutch - Finnish built OMI instrument is part of the NASA's EOS Aura satellite payload. The OMI project is managed by KNMI (PI Pieter Levelt) and the Netherlands Space Agency (NSO). The Planetary Boundary Layer SO₂ product (PBL OMSO2 v1.2.0) is publicly available from the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC) (http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omso2_v003.shtml).

The NASA standard SP tropospheric NO₂ product (OMNO2 version 2.1) is publicly available from NASA GES DISC at http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2_v003.shtml.

Technical Description of Figures:

OMI regional NO₂ maps show annual average 2005 tropospheric NO₂ vertical column density [10^{15} molecules cm⁻²].

OMI regional SO₂ maps show annual average 2005 boundary level SO₂ vertical column density [Dobson Units].

1 Dobson Unit (DU) = 2.69×10^{16} [molecules cm⁻²].

Timeseries plots show percent change in annual average NO₂ and SO₂ relative to the 2005 for regions outlined in the maps

Scientific significance, societal relevance, and relationships to future missions:

Space-based monitoring plays an increasingly important role in the science of tropospheric chemistry and air quality applications to help mitigate anthropogenic and natural impacts on climate, sensitive ecosystems, and human health. US Environmental Protection Agency's (EPA) uses OMI NO₂ data in Air Trends Report (<https://gispub.epa.gov/air/trendsreport/2016>). It is essential to continue and maintain overlapping long-term satellite data records. The baseline established during the first 12 years of OMI is invaluable for the interpretation of measurements from future satellite atmospheric chemistry missions.

The OMI measurements will be continued by the TROPOspheric Monitoring Instrument (TROPOMI), which is planned for launch on ESA's Sentinel 5 Precursor (S5P) satellite in 2016. TROPOMI is part of the European Sentinel series that will continue the global pollution data record for another 20 years. The space-based capabilities for air quality applications will be further enhanced by the addition of higher-ground resolution hourly observations from the three geostationary satellites over North America (NASA's first EV-I Tropospheric emissions: monitoring of pollution (TEMPO), <http://tempo.si.edu>), over Europe (ESA's and Copernicus Sentinel 4 UVN) and East Asia (Geostationary Environment Monitoring Spectrometer (GEMS) on board the GeoKOMPSAT satellite). This atmospheric composition constellation will allow for unprecedented observations of the key pollutants in the atmosphere during next decade.